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## TECHNOLOGICAL SPECIFICS OF USING MARSHALITE IN CONTAINER GLASS PRODUCTION

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The possibility of using marshalite from the Elbashinskoe deposit in the production of container glass is described. The physicochemical characteristics of marshalite and its effect on batch preparation, melting, and quality of glass are identified.

The production technology of most industrial glasses is based on using silica-bearing material, which is the main component of a glass batch. Silicon oxide is introduced into the batch via different kinds of natural silica: quartz sand, sandstone, quartzite, rock crystal, and vein quartz. The most common material is quartz sand, which does not require preliminary crushing and technologically is the most suitable. The main suppliers of high-quality material for glass production are mining-and-concentration works that mine natural sand deposits in central parts of Russia. The substantial cost of transporting this material to remote regions and the increasing demand for it has motivated glass producers to search for alternative sources of high-quality materials [1].

One of the ways for solving the problem of raw material deficit in the glass industry is the effective integrated utilization of local material resources. Glass factories in Siberia are interested in marshalite from the Elbashinskoe deposit (Novosibirsk Region), whose total reserves are estimated at 1.8 million tons.

The purpose of the present study is to investigate the possibility of using marshalite from this deposit in the production of container glass.

Marshalite is a loose (weakly consolidated) monomineral rock, which is the residual product of the erosion of quartzite, siliceous lime, or some other siliceous rocks.

The main condition for the acceptability of silica-bearing materials in glass production is the compliance of its chemical and granulometric composition with the state standard requirements. According to the chemicals analysis of an average sample (Table 1), the main difference between marshalite from quartz sand and that from the Tashlinskoe deposit traditionally used in glass production is the relatively low content of silicon oxide and the increased content of impurities, including colorant impurities. Calcium and magnesium oxides are not undesirable impurities, and their content can be easily corrected in developing a batch formula.

The relatively high content of  $\text{Al}_2\text{O}_3$  in marshalite is due to the presence of alumina-bearing impurities, mainly in the form of kaolin grains and kaolin-containing aggregates, which is corroborated by x-ray phase analysis, where marshalite is represented mainly by  $\beta$ -quartz and kaolinite (Fig. 1).

The most suitable granulometric composition of sand for glass production is sand with a prevailing grain size of 0.1–0.4 mm. In non-concentrated sand the content of the fraction below 0.1 mm should not exceed 15%.

Marshalite in its natural state is a finely dispersed material (Fig. 2) containing, according to the data of comparative sieve analysis (Fig. 3), 60% particles of size 0.10–0.25 mm, whereas sand from the Tashlinskoe deposit has 90% particles of size 0.16–0.50 mm.

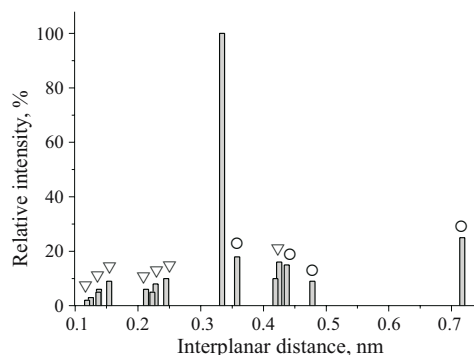
Particles larger than 0.5 mm whose content in marshalite is 10–11% constitute strong gray-color conglomerates of irregular shape. Additional analysis of the granulometric composition of this fraction using the Rutkovskii method [2] indicates the presence of argillaceous particles whose quantity in marshalite is 20–25%.

The practice of glass production shows that a relatively high content of the finely dispersed fraction, as well as the presence of argillaceous particles, increases the propensity of the batch for clotting and disturb its chemical homogeneity [3]. The results of the experiments where the batch is prepared by mixing its components in a blade mixer (for 2 min)

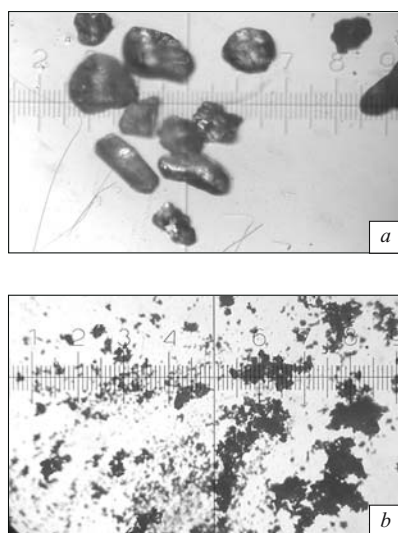
TABLE 1

Silica-bearing material	Mass content, %					
	$\text{SiO}_2$	$\text{Al}_2\text{O}_3$	CaO	MgO	$\text{Fe}_2\text{O}_3$	calcination loss
Marshalite:						
initial	95.70	2.10	1.00	0.40	0.27	0.53
concentrated	97.43	—	1.40	0.70	0.15	0.32
Quartz sand	98.50	0.60	—	—	0.03	0.87

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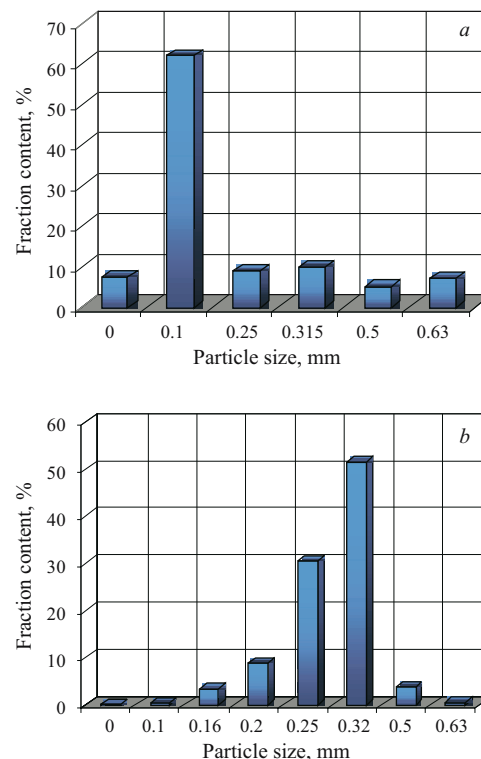
**Fig. 1.** X-ray diffraction diagram of marshalite: ○) kaolinite; ▽) quartz.



**Fig. 2.** Microphotos of silica-bearing materials ( $\times 63$ ): *a*) quartz sand, *b*) marshalite.

show that the replacement of quartz sand by marshalite prevents getting a chemically homogeneous batch. The deviation in the content of  $\text{Na}_2\text{CO}_3$  when 100% sand is replaced by marshalite is equal to  $\pm 5.0 - 5.5\%$ , whereas the state standard prescribes such deviation to be no higher than  $\pm 1\%$ . Furthermore, the formation of large conglomerates, which are mainly a mixture of high-melting materials, increases the propensity of the batch for clotting and, therefore, may have a negative effect on the glass melting process.

In order to improve the quality of marshalite, it was concentrated by the rinsing method. The sieve analysis results



**Fig. 3.** Granulometric composition of marshalite (*a*) and sand from Tashlinskoe deposit (*b*).

indicate that concentrated marshalite is a more monodispersed material that contains 80 – 85% particles of size not more than 0.1 mm. The chemical analysis of concentrated marshalite corresponds to the grade PB (Table 1) and is suitable for making jars and bottles of semiwhite glass. Despite its acceptable chemical composition, the relatively high dispersion of marshalite creates certain difficulties with respect to using it in glass technology: dusting, stratification, and caking of the finely dispersed batch during its storage, transportation, and charging into a furnace. An effective method for eliminating these drawbacks is the consolidation of the glass batch [4 – 6].

Comparative experiments in consolidating glass batches were performed by the pelletizing method on a plate granulator with plate diameter 0.5 m, rotational speed  $38 \text{ min}^{-1}$ , and a slope angle of  $47^\circ$ , moistening the batch with water ( $18 - 20^\circ\text{C}$ ). Batches for semiwhite glass were developed according to the factory formula using traditional materials (soda, dolomite, alumina, sodium sulfate) and sand or fully replacing sand with concentrated marshalite (Table 2).

**TABLE 2**

Composition	Content, weight parts					
	sand	marshalite	soda	dolomite	alumina	sodium sulfate
Industrial, based on sand	73.10	—	22.96	22.81	1.35	1.15
100% sand replaced by marshalite	—	75.05	23.65	20.50	0.99	1.17

TABLE 3

Batch based on	Pelletizing duration, min	Moisture of granules, %	Yield of granules (5 – 7 mm), %	Compressive strength of granules, MPa
Quartz sand	15 – 20	23 – 24	70 – 75	0.15 – 0.20
Concentrated marshalite	12 – 15	21 – 22	90 – 95	0.25 – 0.30

The technical parameters of granulation are given in Table 3. Analysis of the data shows that the introduction of marshalite stabilizes the granulation process: the yield of acceptable granules is 90 – 95%, the mechanical strength of granules grows, while their moisture increases insignificantly. The chemical homogeneity of granules (deviation in the weight content of  $\text{Na}_2\text{CO}_3$  is  $\pm 1\%$ ) satisfies the state standard requirements.

To estimate the effect of marshalite on the melting process and glass quality, we performed a series of laboratory meltings of container glass of the following composition (wt.%): 72.00  $\text{SiO}_2$ , 11.30 ( $\text{CaO} + \text{MgO}$ ), 13.80 ( $\text{Na}_2\text{O} + \text{K}_2\text{O}$ ), 2.15  $\text{Al}_2\text{O}_3$ , 0.35  $\text{Fe}_2\text{O}_3$ , and 0.40  $\text{SO}_3$ .

Melting was performed in corundum crucibles in a furnace with Silit heaters. The maximum melting temperature was 1400°C with 30 min exposure. The activity of granulated batches at the stage of silicate formation was estimated based on x-ray phase analysis of batch samples taken at a temperature of 1150°C. The results of analysis indicate that when concentrated marshalite is used, the intensity of quartz diffraction maxima decreases and the surface area of the amorphous halo increases, i.e., we observe an increase in the chemical activity of the batch.

The glass melt produced at a temperature of 1400°C was used to produce standard glass samples. Their visual inspection revealed complete melting and clarification of glass. The total light transmission of experimental samples of thickness

TABLE 4

Glass	CLTE, $10^{-7} \text{ K}^{-1}$ , in temperature interval of 20 – 400°C	Density, $\text{g/cm}^3$	Total light transmission, %
Container glass, grade PT	Not more than 92	2.48 – 2.52	At least 80
Based on concentrated marshalite	90	2.51	87

3 mm and industrial container glass determined on a photocolorimeter (Table 4), as well as their physical properties, satisfy the requirements of the industrial standards imposed on semiwhite container glass.

Thus, the possibility of using concentrated marshalite from the Elbashinskoe deposit as a quartz-bearing material in the production of semiwhite container glass is established, provided that the glass batch is consolidated, which is the most effective batch preparation method.

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